

Reform and Practice of the Talent Cultivation Model for Software Engineering Undergraduate-Graduate Articulation Driven by Industry-Education Integration

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Abstract: To address the structural contradictions in the traditional segmented undergraduate-graduate cultivation model for software engineering, such as superficial industry-education integration, fragmented competence development, and lagging research training, this paper proposes a reform scheme for cultivating outstanding scientific and technological innovation talents driven by industry-education integration and characterized by integrated undergraduate-graduate cultivation. This model aims to cultivate outstanding scientific and technological innovation talents with innovative spirit, practical capabilities, and an international perspective. By constructing a vertical “curriculum chain” articulation system to break down institutional barriers between undergraduate and graduate education, implementing four-tier progressive project training—“course projects—science and innovation competitions—graduation design—degree thesis”—to strengthen innovation capability, building a school-enterprise collaborative education platform to deepen industry-education integration, and establishing a multi-dimensional evaluation and continuous improvement mechanism to ensure cultivation quality, it forms a five-in-one cultivation system of “industry demand guidance—curriculum system articulation—progressive project training—school-enterprise collaborative education—closed-loop quality assurance.” Taking the Software Engineering major at Dalian Jiaotong University as the practical carrier, this scheme has a solid implementation foundation and promotion value, and is expected to provide a replicable and promotable reform scheme for the cultivation of outstanding scientific and technological innovation talents in software engineering.

Keywords: Industry-education integration; Undergraduate-graduate articulation; Software engineering; Talent cultivation model; Outstanding scientific and technological innovation talents

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1. Introduction

The rapid development of emerging technologies such as artificial intelligence, big data, and cloud computing has imposed higher requirements on the knowledge structure, practical ability, and innovative literacy of

software engineering talents. However, the traditional “segmented undergraduate-graduate” cultivation model has exposed increasingly prominent structural contradictions in the cultivation of outstanding scientific and technological innovation talents in software engineering: vertical discontinuity in the curriculum system, with undergraduate and graduate courses being mutually independent and insufficient progressive articulation of knowledge; superficial industry-education integration, where school-enterprise cooperation mostly remains at the internship level and enterprise resources are not deeply integrated into the entire talent cultivation process; and fragmented cultivation of research and innovation capabilities, where undergraduates lack early research training channels and do not encounter frontier topics until the graduate stage.

In response to the above difficulties, domestic scholars have actively explored solutions from different perspectives. In terms of undergraduate-graduate articulation and integrated cultivation, Harbin Institute of Technology, Shenzhen ^[1] proposed a new management model for integrated undergraduate-graduate talent cultivation; Guo *et al.* ^[2] constructed an internationalization-oriented integrated undergraduate-graduate talent cultivation system; and Hu *et al.* ^[3] explored the construction path of an innovative undergraduate-graduate talent cultivation model from the perspective of science and engineering. In terms of industry-education integration and practical teaching, researchers have proposed an innovative practical teaching model for software engineering based on industry-education integration ^[4], a “12345” government-industry-university-research-application integrated innovative talent cultivation system ^[5], and a “1364” practical teaching model for software talents ^[6]. In addition, some scholars, guided by the OBE concept, proposed an applied practical teaching framework of “dual-mentor guidance, three-dimensional linkage, and four-stage progression” ^[7]; Ren *et al.* ^[8], taking Xi’an Eurasia University as an example, explored an innovative talent cultivation model for software engineering under the approach of new engineering discipline construction; and other studies, from the perspective of school-enterprise collaborative education, proposed a teaching system construction scheme under the integrated innovation paradigm ^[9], as well as a practical pathway for cultivating “Software Engineering + Big Data” interdisciplinary talents through industry-education integration ^[10]. The above studies provide abundant theoretical resources for the reform of software engineering talent cultivation; however, the two main reform lines of industry-education integration and undergraduate-graduate articulation have not yet been systematically integrated, and the chain for cultivating research and innovation capabilities from undergraduate to postgraduate stages still lacks a coherent design.

To this end, this paper proposes a reform scheme for cultivating outstanding scientific and technological innovation talents driven by industry-education integration and characterized by integrated undergraduate-graduate cultivation. This model aims to cultivate outstanding scientific and technological innovation talents with innovative spirit, practical capabilities, and an international perspective. By constructing a vertical “curriculum chain” articulation system to break down institutional barriers between undergraduate and graduate education, implementing four-tier progressive project training—“course projects—science and innovation competitions—graduation design—degree thesis”—to strengthen innovation capability, building a school-enterprise collaborative education platform to deepen industry-education integration, and establishing a multi-dimensional evaluation and continuous improvement mechanism to ensure cultivation quality, it forms a five-in-one cultivation system of “industry demand guidance—curriculum system articulation—progressive project training—school-enterprise collaborative education—closed-loop quality assurance.” Taking the Software Engineering major at Dalian Jiaotong University as the practical carrier, this paper systematically elaborates the design concepts and implementation pathways of the reform scheme, in order

to provide a replicable and promotable reform example for the cultivation of outstanding scientific and technological innovation talents in software engineering.

2. Reform scheme design

2.1. Overall approach

The reform takes “industry-education integration-driven and integrated undergraduate-graduate cultivation” as its core concept, aims to cultivate outstanding scientific and technological innovation talents with innovative spirit, practical capabilities, and an international perspective, and conducts systematic reform in four dimensions: cultivation system, teaching model, practical platform, and quality assurance. It constructs a five-in-one cultivation model of “industry demand guidance–curriculum system articulation–progressive project training–school-enterprise collaborative education–closed-loop quality assurance.”

2.2. Cultivation system: Building an integrated framework of “vertical coherence and horizontal interdisciplinarity”

2.2.1. Design of a vertical “curriculum chain”

Break down the institutional barriers between undergraduate and graduate education and formulate an integrated through-training program. Through the vertical “curriculum chain” design, progressive articulation of the knowledge system is achieved: systematically connecting the undergraduate course “Software Engineering” with the master’s course “Advanced Software Engineering,” and integrating the undergraduate “Data Structures and Algorithms” with the master’s “Advanced Algorithm Analysis and Design,” thereby realizing undergraduate-graduate articulation in core courses, avoiding duplication of teaching content and discontinuities in the knowledge system. At the same time, a dynamic streaming mechanism based on academic performance and innovation potential is established to provide flexible undergraduate-graduate articulation pathways for outstanding undergraduates.

2.2.2. Establishment of horizontal interdisciplinary modules

Cross-disciplinary modules such as “Software Engineering + Artificial Intelligence,” “Software Engineering + Data Science,” and “Software Engineering + Rail Transit” are set up to promote multidisciplinary knowledge integration. Leveraging the rail transit disciplinary characteristics of Dalian Jiaotong University, industry needs in rail transit are deeply integrated into the curriculum system, and specialized courses such as Rail Transit Big Data and Intelligent Transportation Systems are offered, enabling students to acquire professional qualities for serving specific industries while mastering core software engineering knowledge. Disciplinary integration helps broaden students’ knowledge breadth and construct a three-dimensional competence structure through cross-domain knowledge integration.

2.2.3. Front-loading research training

A research mentorship system and early intervention mechanism are implemented. Undergraduate students are assigned dual-mentor teams comprising on-campus and enterprise mentors, guiding them to integrate into research teams from the early years and participate in academic activities and research projects. Through linked undergraduate-postgraduate cultivation, students gain research practice experience during the undergraduate stage, effectively shortening the research adaptation period after entering postgraduate study, and forming a collaborative

education pattern of “multi-party integration, complementary strengths, and mutual advancement of research and development” among undergraduates, master’s students, enterprise engineers, and supervisors.

2.3. Teaching model: Strengthening “four-tier progressive” innovation capability training

With project-driven learning as the core, a four-tier progressive project training system of “course projects—science and innovation competitions—graduation design—degree thesis” is constructed.

Tier 1 (Course Projects): Real enterprise needs are transformed into course cases, allowing students to engage with practical problems in the early undergraduate years. With the core concept of “promoting teaching through application, promoting learning through application, and integrating learning with application,” a hierarchical and progressive practical teaching system is constructed, which can effectively enhance students’ problem awareness and problem-solving ability.

Tier 2 (Science and Innovation Competitions): Students are encouraged to participate in disciplinary competitions such as the Challenge Cup, Internet Plus, and Lanqiao Cup, using competitions to test and stimulate innovation capability.

Tier 3 (Graduation Design): Graduation design topics should originate from real school-enterprise cooperation projects and be jointly supervised by on-campus and enterprise mentors, completing full-process training from requirements analysis to system implementation.

Tier 4 (Degree Thesis): After entering the postgraduate stage, students conduct in-depth academic research based on prior research training, naturally extending the research foundation accumulated during the undergraduate stage into their master’s degree thesis work.

The four-tier progressive project training system (see **Figure 1**) integrates the cultivation of research literacy throughout the entire undergraduate program and extends it into the postgraduate stage, achieving stepwise growth in competence.

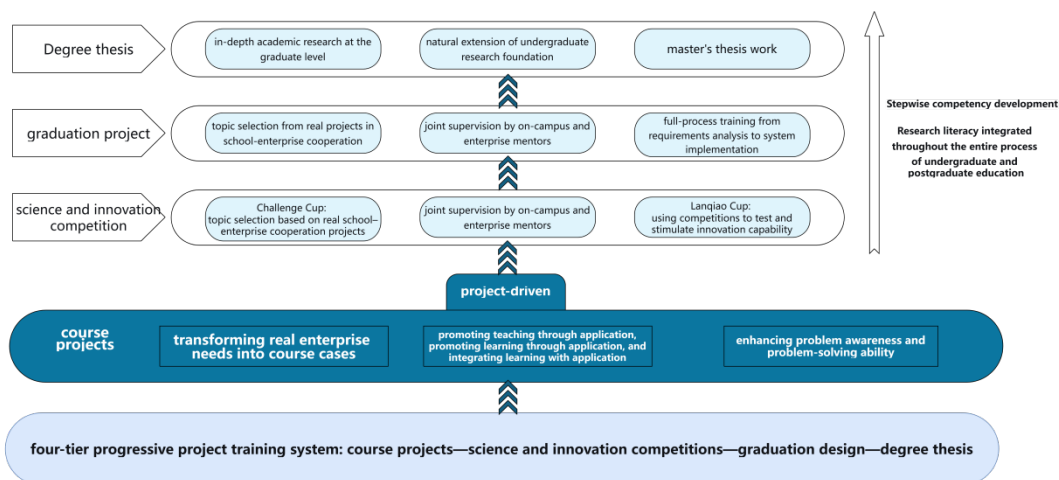


Figure 1. Four-tier progressive project training system

2.4. Industry–education integration: Building a practical ecosystem of “collaborative talent cultivation and resource sharing” (Figure 2)

2.4.1. Construction of joint university–enterprise laboratories

Enterprise-level development platforms have been introduced to jointly establish a university–enterprise

joint laboratory for “Intelligent Software Engineering.” Dalian Jiaotong University has already established specialized laboratories such as the Alibaba Big Data Laboratory, Artificial Intelligence Laboratory, and Cloud Computing Laboratory, and has maintained long-term cooperative relationships with enterprises including Huawei, Alibaba, and Baidu, thereby ensuring the quality of cultivating students’ engineering practice capabilities.

2.4.2. Building a double-qualified teaching team

Enterprise experts are employed to offer customized courses, while on-campus teachers are selected to take temporary positions in enterprises for practical training, forming a two-way empowerment mechanism. Drawing on the cooperation model of “enterprises propose demands, universities and enterprises jointly formulate solutions, experts enter the classroom, and enterprises evaluate outcomes,” a joint industry–education review mechanism has been established. Among the full-time teachers of the School of Rail Intelligent Engineering at Dalian Jiaotong University, there are both teaching and research backbone faculty and senior specialized talents from enterprises, providing faculty support for double-qualified teaching.

2.4.3. Practice bases and internship system

Phased enterprise internship bases have been established, and a three-tier internship system of “on-campus practice–enterprise practical training–post-based internship” has been constructed. Dalian Jiaotong University has been approved by the Ministry of Education as a “National Engineering Practice Education Center” and the “Dalian Jiaotong University–Chinasoft International Off-Campus Practice Base,” and has established long-term cooperative relationships with enterprises such as CRRC, Neusoft, Huaxin, and Chinasoft International. Students are arranged to undertake a one-semester enterprise internship and complete their graduation design, effectively shortening the job adaptation period.

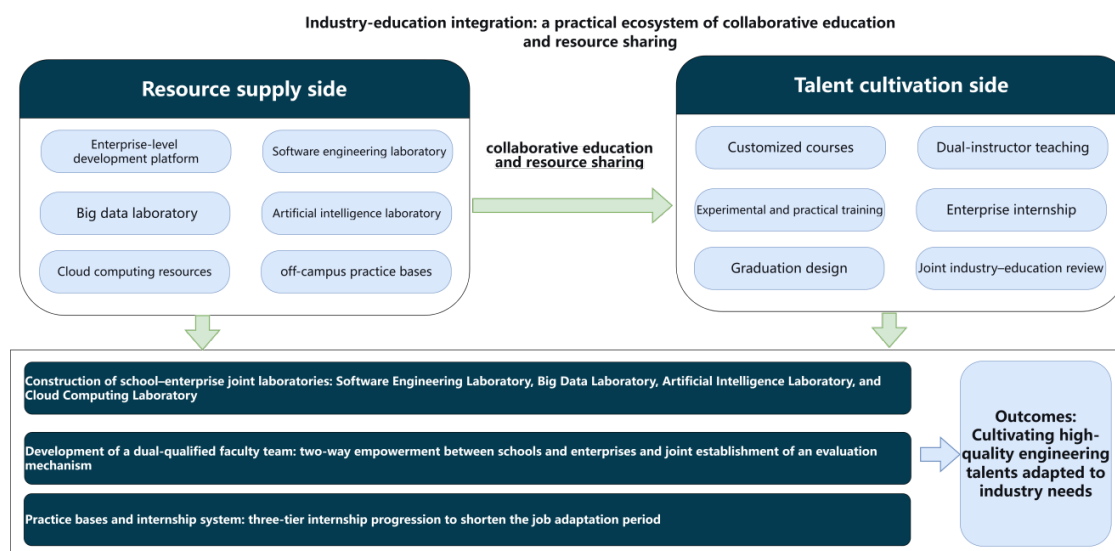


Figure 2. Practical ecosystem of collaborative talent cultivation and resource sharing

2.5. Quality assurance: Establishing a closed-loop system of “multiple evaluation and continuous improvement”

2.5.1. Multiple evaluation indicator system

Breaking through the traditional score-only evaluation model, a multiple assessment indicator system covering academic papers, patent applications, competition awards, project outcomes, and enterprise evaluations has been established. The evaluation system should include process-based evaluation and value-added evaluation, dynamically tracking students' research data, project outcomes, and competency growth trajectories.

2.5.2. Teaching steering committee and feedback mechanism

A Teaching Steering Committee composed of university, enterprise, and industry experts has been established to conduct regular evaluations. A graduate tracking and feedback mechanism has been established to continuously optimize training objectives, curriculum systems, and teaching methods based on feedback data and industry dynamics, thereby forming a sustainable quality improvement cycle.

3. Practical exploration

3.1. Implementation foundation

The School of Rail Intelligent Engineering (School of Software) at Dalian Jiaotong University has a first-level discipline master's degree authorization point in Software Engineering and a National First-Class Undergraduate Major Construction Point. The school has established provincial and ministerial-level platforms such as the “Liaoning Provincial Engineering Research Center for Informatization of Rail Transit Equipment Manufacturing” and the “Liaoning Provincial Training Base for Service Outsourcing to Japan.” The school maintains long-term cooperation with enterprises such as Huawei, Alibaba, Baidu, Neusoft, and Chinasoft International. The project team is composed of outstanding teachers from Software Engineering, Big Data, and Artificial Intelligence majors, all of whom are master's supervisors with years of graduate supervision experience, possessing solid professional research capabilities and rich teaching experience. The team has previously accumulated substantial achievements in Ministry of Education industry-university cooperative education projects, curriculum system reform, and textbook development, providing a solid foundation for this project research.

3.2. Implementation path planning

In the Software Engineering major, the implementation path of the “on-campus + enterprise” dual-mentor system and the four-tier project training system is planned. Specific measures include: designing a mechanism for assigning mentors to lower-grade students to participate in research team activities; planning an organizational model for middle- and higher-grade students to enter laboratories for systematic research training; formulating a teaching plan that integrates real enterprise projects throughout courses and practical sessions; and constructing the functional architecture of a digital management platform to support dynamic tracking of student growth data.

3.3. Expected outcomes

Through the theoretical research and scheme design of this project, the following outcomes are expected after

implementation:

Significant increase in research participation rate. Through the early research intervention mechanism, the proportion of pilot students participating in research projects or disciplinary competitions is expected to be significantly higher than that under the traditional training model.

Continuous output of innovative achievements is expected. Through the four-tier training system of “course projects–science and innovation competitions–graduation design–degree thesis,” students’ participation and award levels in competitions such as the “Internet Plus” Innovation and Entrepreneurship Competition, the “Challenge Cup” Extracurricular Academic Science and Technology Works Competition, and the Lanqiao Cup Programming Competition are expected to increase significantly.

The transition adaptation period from undergraduate to graduate study is shortened. Through the integrated undergraduate-graduate course chain design and early research training, students’ research starting point and topic adaptation speed after entering graduate study are expected to be superior to those under the traditional training path.

Deep advancement of industry-education integration. Through the systematic design of university-enterprise joint courses and practical projects, students’ engineering practice capabilities are more aligned with industry needs, and graduates’ employment competitiveness is expected to steadily improve.

4. Conclusion and outlook

Aiming at the drawbacks of the traditional segmented undergraduate-graduate training in Software Engineering, this paper proposes an outstanding scientific and technological innovation talent training model driven by industry-education integration and integrated undergraduate-graduate education. Through constructing a vertical “course chain” articulation system, implementing “four-tier progressive” project training, building a university-enterprise collaborative education platform, and establishing a multiple quality assurance mechanism, this model forms a five-in-one training system of “industry demand guidance–curriculum system articulation–progressive project training–university-enterprise collaborative education–closed-loop quality assurance.” This scheme is based on the Software Engineering major of Dalian Jiaotong University and has a solid implementation foundation and promotion value.

Subsequent research will be deepened in three aspects: first, steadily advancing pilot implementation in the Software Engineering major to verify the effectiveness of the model and accumulate empirical data; second, improving the construction of the digital management platform to achieve dynamic tracking of student growth trajectories; third, radiating and promoting mature experience to majors such as Artificial Intelligence and Big Data, expanding the benefits of reform, and providing a replicable practical example for the cultivation of outstanding scientific and technological innovation talents in Software Engineering.

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